Metals **2015**, *5*, 2393-2396; doi:10.3390/met5042393

OPEN ACCESS

metals

ISSN 2075-4701

www.mdpi.com/journal/metals/

Editorial

Ultrafine-Grained Metals

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Received: 10 December 2015 / Accepted: 10 December 2015 / Published: 16 December 2015

Ultrafine-grained (UFG) metallic materials are at the cutting edge of modern materials science as they exhibit outstanding properties which make them very interesting for prospective structural or functional engineering applications. Due to the progress in severe plastic deformation techniques during the last decade, ultrafine-grained microstructures are no longer only restricted to easy to deform single-phase materials, but can also be introduced in complex and hard to deform alloys of technological relevance. Nowadays it is of course clear that not only the hardening effect by the well-known Hall-Petch law is of high importance in UFG materials, but many other issues also come into play. This Special Issue on ultrafine-grained metals covers a broad range of research activities in that field. Fifteen articles have been selected for this issue addressing manifold topics such as new developments in severe plastic deformation techniques, advances in modeling and simulation of the severe plastic deformation processes, mechanical properties under monotonic and cyclic loading of homogenous and graded UFG structures and, related to that, dominating deformation mechanisms in UFG materials. Furthermore, advances and strategies for high conductivity materials by introducing UFG structures; the correlation between severe plastic deformation parameters and the resulting materials properties; and peculiarities in the corrosion behavior of UFG materials, have been addressed.

The 15 articles reflect, on the one hand, the variety of state of the art research activities in the field and, on the other hand, form the spearhead of current advances. The articles are briefly summarized as follows:

- Murashkin *et al.* [1] studied the influence of an ECAP-conform process on the mechanical properties and the electrical conductivity of an AA6101 alloy. They found out that both the electrical conductivity and the mechanical strength can be significantly increased by this process when the data are compared to the T6 or T81-CG counterparts.
- Sajadifar and Yapic [2] modified a Johnson-Cook model in order to predictively describe the flow behavior of UFG titanium at elevated temperatures, which also aims to describe high-temperature forming processes.

- Murdoch *et al.* [3] succeeded in introducing a graded grain structure by applying a surface mechanical attrition treatment (SMAT) to a bcc iron plate at ambient and cryogenic temperatures.
- Rufing *et al.* [4] showed that a high-pressure torsion (HPT) process applied to an SAE1045 steel results in a significantly enhanced endurance limit. They also showed that the fatigue crack initiation mechanisms were changed by the severe plastic deformation.
- Another contribution in the field of fatigue, by Köhler *et al.* [5], deals with the influence of an ECAP-process on unreinforced and particulate reinforced AA2017 on the fatigue crack growth behavior.
- Lee *et al.* [6] investigated the potential of multi-pass caliber rolling of Ti6Al4V to obtain an UFG microstructure in larger quantities. It was also found that the material in the UFG state exhibits superplastic behavior.
- Altenberger *et al.* [7] addressed the increasing demand in the industry for highly conductive high strength copper alloys. New strategies are shown to achieve a high strength paired with good conductivity by introducing an UFG microstructure. Furthermore, the role of precipitates for thermal stability is investigated and promising concepts and alloy systems for the future are proposed and discussed.
- Ruppert *et al.* [8] subjected the austenitic stainless steels X4CrNi18-12 and X8CrMnNi19-6-3 to the ARB-process and obtained rather high yield strengths of more than 1.25 GPa paired with a high ductility. It was shown that micro-twinning comes into play.
- High pressure torsion was used by Krämer *et al.* [9] to produce bulk metallic glass by severe plastic deformation. They consolidated Zr-based metallic glass powder and deform it further to weld the powder particles together.
- Odnobokova *et al.* [10] studied the effect of large strain cold rolling at ambient temperature on a 304 L stainless steel. They found that deformation twinning followed by micro-shear banding and martensitic transformation promoted the development of a nanocrystalline structure with an extraordinary high yield strength of 1.6 GPa.
- Murashkin *et al.* [11] reported on the monotonic and cyclic properties of an ultrafine-grained Al 6061 alloy processed by high-pressure torsion. A significant improvement of the monotonic strength as well as the fatigue strength is reported.
- Ebrahimi *et al.* [12] investigated a rather new SPD-process, called equal channel forward extrusion, and obtained rather similar properties and microstructures as obtained by other severe plastic deformation methods.
- Semenova *et al.* [13] consolidated cryogenic milled Ti-powder by high pressure torsion and investigated the obtained microstructures. Grains smaller than 40 nm have been obtained.
- Nickel *et al.* [14] studied the effect of strain localization on pitting corrosion of an AlMgSi0.5 alloy. It was found that more pits emerge in shear bands, but the pit depth is reduced significantly. Moreover, stable pitting of shear bands results in less positive potentials compared to adjacent microstructures.
- Ma *et al.* [15] applied multi-pass equal-channel angular pressing (EACP) to produce ultrafine-grained Cu-0.2 wt % Mg alloy contact wires. They showed that Cu-Mg alloy after multi-pass ECAP at 473 K exhibit a high strength paired with satisfactory conductivity.

In summary, these 15 articles excellently highlight the diversity of research in the field of ultrafine-grained metals and offers a snapshot of current activities in the field. The obtained results clearly show, on the one hand, the high potential of UFG materials; and on the other hand, although the first research activities in the field were started in the early 1980s, it becomes obvious that there are still plenty of open topics to be investigated. As stated in the beginning: The potential of ultrafine-grained materials is not only related to a high strength according to the Hall-Petch law but also to many other issues that come up or change with grain size.

Conflicts of Interest

The authors declare no conflict of interest.

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